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GOLDEN GATE BRIDGE MOVEABLE MEDIAN BARRIER

Authorize Conceptual Approval for
Installation of Barrier Systems, Inc.
One Foot Wide Moveable Median Barrier

Prepared for

Building & Operating Committee/Committee of the Whole

May 1, 1998

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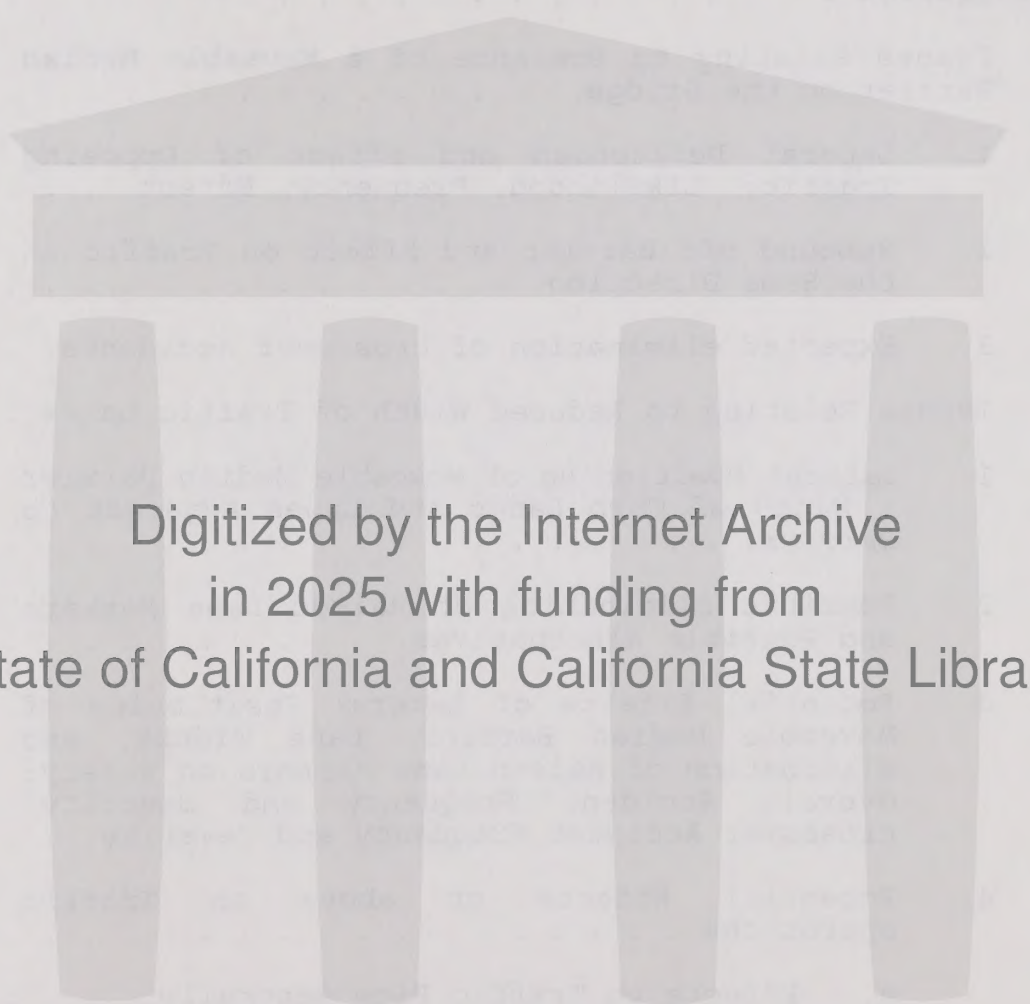
May 1, 1998

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Attachments

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AGENDA ITEM 1
GOLDEN GATE BRIDGE, HIGHWAY AND TRANSPORTATION DISTRICT

MERVIN C. GIACOMINI, P.E.

DISTRICT ENGINEER

Apr 27, 1998
For: May 01, 1998

TO: Building & Operating Committee/
Committee of the Whole
FROM: Mervin C. Giacomini, District Engineer
SUBJECT: GOLDEN GATE BRIDGE, MOVEABLE MEDIAN BARRIER -
AUTHORIZE CONCEPTUAL APPROVAL FOR INSTALLATION OF
BARRIER SYSTEMS, INC. ONE FOOT WIDE MOVEABLE MEDIAN
BARRIER (ACTION)

I. INTRODUCTION

This report will (1) summarize the background of the studies, tests, and prior District meetings concerning consideration of a moveable median barrier for possible installation on the Golden Gate Bridge, (2) address staff's analysis to date of the issues that the Committee of the Whole at its January 16, 1998 meeting identified as those which need to be resolved in order to reach a conceptual decision of whether or not to install the one foot wide moveable median barrier on the Golden Gate Bridge, and (3) set forth staff's recommendation that the Building and Operating Committee give conceptual approval to the installation of the one foot wide moveable median barrier developed by Barrier Systems, Inc. ("BSI") on the Golden Gate Bridge and that the Committee so recommend to the full Board.

The background summary is set forth in detail in the attached Appendix A. The main body of this report will focus on those issues whose resolution has been deemed to be prerequisite to a conceptual decision concerning possible installation, and upon staff's recommendation.

II. SUMMARY OF RECOMMENDATION

As indicated in the Introduction, staff recommends that the Building and Operating Committee give conceptual approval to the installation of the BSI one foot wide moveable median barrier on the Golden Gate Bridge, actual installation to be subject to satisfactory resolution of those previously identified issues which must be resolved after the conceptual decision to install has been reached. The recommendation has been unanimously endorsed by the Moveable Median Barrier Advisory Committee appointed by the Board. This recommendation is premised on a conclusion that, on balance, the expected primary benefit that will be achieved by installation of the barrier - virtual elimination of cross-over accidents - outweighs the various detriments, risks, and uncertainties installation would involve.

As set forth in the Conclusion of this report, the question of whether or not to install the one foot wide moveable median barrier, given the unique physical characteristics and circumstances which exist respecting the Golden Gate Bridge, is neither easy to resolve nor susceptible of a single clear cut answer. A decision either to install or not to install the barrier has identifiable pros and cons, and risks and benefits, requiring a number of tradeoffs. A reasonable Board could go either way on the issue, depending on how it weighed the competing factors and how it chose to balance the various tradeoffs involved.

The recommendation is therefore made with the clear recognition that the Board could weigh the competing considerations differently and reach a contrary decision, and that doing so would be a reasonable and responsible determination. It is also recognized that, should the Board determine that, as a conceptual matter, the barrier should be installed, there are a number of permitting, engineering and funding issues which must be resolved before a final decision to install the barrier can be made and that decision can be implemented.

Because BSI has indicated an unwillingness to install the barrier on a trial basis and, in essence, refund part of its cost, there is no real difference between a "trial" and a "permanent" installation so that it would not appear that a trial installation, suggested by both Northwestern University Traffic Institute and Caltrans, is feasible as a practical matter. However, actual performance of the barrier, if installed, must be monitored and evaluated to ascertain whether it actually performs satisfactorily, given the tradeoffs involved.

Should the Board decide to give conceptual approval of installation of the barrier, it is preliminarily estimated that it would take approximately 24 to 38 months to implement installation.¹

¹Built into this preliminary time estimate is: 1) the 13 month period for the Golden Gate National Recreation Area ("GGNRA") to complete its toll plaza planning activity which would encompass the moveable median barrier project, and in particular, the location, configuration, and design of the repair and maintenance facility for the barrier transfer vehicles; and, 2) the obtaining of the required National Park Service ("NPS") Permit. The 13 month estimate was provided by the GGNRA, and it is hoped that the NPS permit would follow very shortly. These matters are not in staff's control, but staff would use its best efforts to expedite the process.

III. SUMMARY OF STAFF'S ANALYSIS OF ISSUES CONSIDERED IN REACHING RECOMMENDATION OF CONCEPTUAL APPROVAL OF BARRIER INSTALLATION

The Committee of the Whole concurred at its January 16, 1998 meeting that issues relating to reduced width of traffic lanes and issues relating to the presence of a moveable median barrier on the Bridge had to be resolved in order to reach a conceptual decision of whether or not to install the moveable median barrier. The following discussion summarizes staff's analysis of those issues.

A. ISSUES RELATING TO PRESENCE OF A MOVEABLE MEDIAN BARRIER ON THE BRIDGE.

1. Lateral Deflection and Effect of Opposing Traffic: Likelihood, Frequency, Effect.

Crash testing performed in accordance with NCHRP criteria determined the deflection of the Quickchange one foot wide barrier for the following crashes:

- a. A small car with a nominal weight of 1,800 pounds at a speed of 62 miles per hour at an approach angle of 20 degrees deflected the barrier 18 inches.
- b. A pickup truck with a nominal weight of 4,400 pounds at a speed of 62 miles per hour at an approach angle of 25 degrees deflected the barrier 32 inches.

The Northwestern Traffic Safety Study calculated probability of secondary collisions with the deflected barrier by opposing traffic as follows:

- a. A lateral barrier deflection of 18 inches has a probability of secondary collisions of 6 to 9 percent.
- b. A lateral barrier deflection of 30 inches has a probability of secondary collision of 18 to 27 percent.

The report further states that if a 30 inch maximum deflection of the barrier was used, then 12% of the barrier impacts would be expected to result in secondary barrier collisions from opposing traffic.

In applying the potential for secondary accidents to the accident statistics for the period 1991 through 1997, there were 36 recorded cross-over accidents. This average of approximately five cross-over accidents per year would result in 0.6 potential opposing traffic collisions with a

deflected barrier per year. There is little data on the severity of such secondary barrier collisions, therefore it is not possible to calculate the level of injury that would have resulted from these collisions. It should be noted that this analysis does not include non-reported cross-overs not resulting in an accident or other incident but which nonetheless could have resulted in contact with a barrier were one in place, and possible barrier deflection and secondary accidents on the other side of the barrier.

2. Rebound off barrier and effect on traffic in the same direction.

To evaluate collisions resulting from vehicles that rebound off the barrier into adjacent same direction traffic, it is first necessary to evaluate cross-overs where a vehicle crosses over the lane markers separating opposing directions of traffic. The District records record cross-overs in which a vehicle crosses over the lane markers for any reason. Cross-overs can result from side-swipe collisions, rear-end collisions, and loss of driver control. Cross-overs can also be intentional and non-intentional. Non-recorded cross-overs may occur when a vehicle crosses over the line and returns to its original lane without an accident or crosses over into the buffer lane to avoid an accident. For the time period 1991 through 1997, there were 36 recorded cross-over accidents, 12% of the total accidents for that period.

The Northwestern University Traffic Institute Traffic Safety Study conducted an extensive risk analysis of rebound collisions with adjacent traffic and determined that a vehicle traveling 45 miles per hour colliding with the barrier and exiting from the barrier at a 6 degree angle had an 18.6 to 30.6 percent probability of a secondary collision with adjacent traffic. The same vehicle colliding with the barrier and exiting from the barrier at a 12 degree angle would have a 31 to 54.7 percent probability of a secondary accident. If this probability range was applied to the 36 recorded cross-overs for the time period 1991 through 1997, an average of approximately five cross-overs per year, it would result in a minimum of one potential secondary collision per year to a maximum of three potential secondary collisions per year. It is not possible to calculate the level of injury that would have resulted from these collisions. This analysis does not account for non-recorded vehicles that may presently cross over the lane line and return to its original lane without an accident. With the barrier in place,

these vehicles could possibly collide with the barrier and a possible rebound collision with other vehicles.

3. Expected elimination of crossover accidents.

The installation of moveable median barriers on the Auckland Harbor Bridge, Tappan Zee Bridge, and San Diego-Coronado Bridge have eliminated all crossover accidents. Based on the successful crash testing of the one-foot Quickchange moveable median barrier in accordance with the National Cooperative Highway Research Program (NCHRP), it is anticipated that a moveable median barrier on the Golden Gate Bridge would prevent virtually all crossover accidents. The one-foot Quickchange moveable median barrier proposed for the Golden Gate Bridge was tested in accordance with NCHRP Report 350, Test Level 3, which includes crash testing a 4,400 pound pickup truck into the rail at a speed of 62 miles per hour, with an approach angle of 25 degrees.

NCHRP 4,400 pound test vehicle provides a vehicle comparable to the sports utility vehicles on the road today. The barrier was not tested for trucks and buses since these vehicles represent only about 3% of the traffic on the Golden Gate Bridge.

B. ISSUES RELATING TO REDUCED WIDTH OF TRAFFIC LANES:

1. Lateral positioning of moveable median barrier - width of curb lanes and lanes adjacent to barrier.

The Northwestern University Traffic Safety Study analyzed eight different lane configurations with a moveable median barrier in the 3/3 configuration and in the 2/4 configurations. Their criteria for evaluating the eight configurations was as follows:

- a. All lanes should be at least ten feet wide and in no case should any lane be less than nine feet wide.
- b. The outside lanes (curb lanes) should remain eleven feet wide.
- c. The lanes adjacent to a moveable median barrier system should be as wide as possible.
- d. When the roadway is in the 2/4 configuration, the two lane section should be more than twenty feet wide.

None of the analyzed alternatives completely satisfied all the lane width criteria. Northwestern opined that Alternate "E" best

satisfies the criteria. Alternate "E" maintains the 11 foot curb lanes and matches narrow lanes with wide lanes to provide space between parallel vehicles. The following describes Alternate "E" in various configurations: a) The 3/3 configuration: the number one lane, adjacent to the barrier, is 10 feet; the number two lane is 9.5 feet; and, the number three lane, the curb lane, is 11 feet. b) The 2/4 configuration: In the two lane section, the number one lane, adjacent to the barrier, is 10 feet and the number two lane, adjacent to the curb, is 11 feet. For the four lane section, the number one lane, adjacent to the barrier, is 9 feet, the number two lane is 10.5 feet, the number three lane is 9.5 feet, and the number four lane, adjacent to the curb, is 11 feet.

The Bridge Manager and the Bus Transit Manager concur that the curb lanes remain 11 feet wide because District buses are 8.5 feet wide, without accounting for side mirrors, which leaves 2.5 feet of maneuvering space in an 11 foot lane. This space constraint is further compounded by the length of the bus, 40-45 feet, and its sweep path due to the off-tracks of the rear wheels, which results in the bus occupying an additional one foot of space on the curves at the north and south ends of the Bridge. In addition, the overall width of a bus with mirrors is approximately 10 feet, 4 inches wide. Therefore, a bus operator must carefully center his or her bus in an 11 foot lane to prevent the bus from protruding into the other lane.

Staff proposes that in the 4/2 configuration, the existing lane configuration on the Bridge be retained (11 foot curb lanes, 10 foot interior lanes on the four lane side of the barrier). This configuration is listed as "Configuration A" in the Northwestern study. It provides for 11 foot curb lanes and increases the lanes adjacent to the moveable median barrier from 9 feet proposed in Configuration E. However, the 9.5 foot lane would be on both sides of the barrier in lieu of the 9 foot lane on the wider side of the barrier and 10 foot lane on the other side proposed in Lane Configuration E. Configuration A does not require that the existing lane lines on the Bridge be reconfigured. Using this configuration, buffer lanes in non-peak nighttime hours could be established if necessary for traffic safety by placing pylons in the existing sleeves fabricated in the orthotropic deck along the lane lines.

2. Possible elimination of raised lane markers and possible alternatives.

The raised ceramic lane markers along the three interior lane lines interfere with the placement of the moveable median barrier in all eight lane configuration alternatives evaluated including Configuration A. In addition, when the barrier is deflected by a crash, the ceramic lane markers will be disengaged from the roadway. Raised lane markers have over the years been viewed as the most visible means of delineating traffic lanes. Their elimination on the Bridge may reduce lane line visibility and eliminate the audible warning a driver presently receives on crossing a lane line.

Caltrans is evaluating alternatives to ceramic lane markers in the future because of the high maintenance costs in replacing disengaged markers and the short life of the markers due to the loss of reflectability. The alternatives to ceramic lane markers and their advantages and their disadvantages are listed below:

a. *Reflective Thermoplastic Continuous or Dashed Striping.*

Provides a highly visible, subtly audible marking that can be removed and relocated in the event that the lane line configurations are modified in the future. A product known as "Raised Profile Striping" is currently being used in lieu of raised pavement markers on a section of Interstate 5 near Sacramento. Another variety, known as "Inverted Profile Striping," is being used where high visibility is needed, such as on Highway 37.

b. *Recessed Reflective Lane Markers.*

Reflective lane markers placed in grooves in the pavement similar to those used on highways where there are snow conditions provide reflection in either or both directions of traffic, are less audible, and difficult to relocate for future lane configurations.

c. *LDS Strip Lighting.*

Used to a limited extent in airports to guide planes to parking locations; has not been developed for highway usage. Development challenges are the differences in visibility for nighttime versus bright sunlight, cost, and reliability.

3. Potential effects of lateral positioning of moveable median barrier, lane widths, and elimination of raised lane markers on safety: overall accident frequency and severity/crossover accident frequency and severity.

The Northwestern University Traffic Safety Study evaluated the effects of a moveable median barrier on safety on the following four bridges with moveable median barrier to date:

a. Auckland Harbor Bridge.

The bridge has a total of eight lanes. The bridge consists of a through-truss with four lanes and new bridges attached on both sides of the through-truss consisting of two 12 foot lanes in each direction. The moveable median barrier system is installed on a four-lane central through-truss roadway which is 42 feet wide, providing four 10 foot lanes. The four center lanes of the Auckland Harbor Bridge are operated in a 2/2 and 1/3 configuration. The bridge and approaches are 1.37 miles long with 1,100 foot radius curves (5% superelevation) at both ends. The average daily traffic volume is 140,000 vehicles per day.

On the Auckland Harbor Bridge, before the installation of the moveable median barrier, the interior four lanes were 10.5 feet in width and the exterior lanes were conventional 12 foot lanes. In a 46 month period prior to the moveable barrier installation, there were 24 head-on accidents on the bridge, resulting in 11 fatalities, 16 serious injuries, and 20 minor injuries. The accident rate based on two years during this time period (1989-1990) was 2.1 accidents per million vehicle miles. The accident rate after the installation of the moveable median barrier for the time period 1991-1995 was 1.61 accidents per million vehicle miles.

b. San Diego-Coronado Bridge.

A moveable median barrier on a bridge roadway 62 feet wide, with four 12 foot lanes and a 14 foot center lane. The barrier is 8,100 feet (1.53 miles) long, and includes a 1,800 foot radius curve. The 1995 average daily traffic volume was 65,000 vehicles per day.

Originally, the San Diego-Coronado Bridge consisted of three center 12 foot wide lanes and 13 foot wide curb lanes. Prior to the

installation of the moveable median barrier, the bridge was operated in a 2/3 configuration by placing 18 inch plastic pylons into sleeves set into the roadway along the lane lines.

The accident rate for the period of 1988 through 1992 before the installation of the moveable median barrier was 0.98 accidents per million vehicle miles. The accident rate after the installation of the moveable median barrier for the period of 1993-1995 was 0.71 accidents per million vehicle miles.

c. Tappan Zee Bridge.

A moveable median barrier on a bridge roadway seven lanes wide operated in a 4/3 lane configuration at all times. All lane widths are approximately 11.5 feet, with a six inch clear space between the lane line and the curb, and a three inch clear space between the lane line and the moveable median barrier during peak hour configuration. The non-peak hour configuration provides for three 11.5 foot lanes in each direction with a clear space between the lane lines for the lane adjacent to the barrier of six feet.

Prior to the installation of the moveable median barrier on the Tappan Zee Bridge, the bridge was operated in a configuration of four lanes eastbound and three lanes westbound separated by a steel median barrier.

The moveable median barrier system is 18,000 feet (3.41 miles) long. The 1996 average daily traffic volume was 121,600 vehicles per day, of which 6% was commercial vehicles.

The Northwestern University Traffic Safety Study noted that accident statistics were not available prior to the installation of the moveable median barrier and that the high injury and fatal accident rates, 2.59 per million vehicle miles for the period 1994-1996, could not be explained. We attempted to obtain additional accident data from the Bridge Authority but were only able to obtain the data for 1997. The injury and fatal accident rate on the Tappan Zee Bridge in 1997 was 0.58 per million vehicle miles. Because of the limited extent of information available, the Tappan Zee Bridge statistics, like those of the Genvilliers Viaduct, are of some, but limited utility.

d. Genvilliers Viaduct.

A moveable median barrier installation with four 9.8 foot lanes plus a 12.8 foot center reversible lane and 3.3 foot outside shoulders. The roadway carried 115,000 vehicles per day.

Prior to the installation of a moveable median barrier, the Genvilliers Viaduct had a fixed median barrier with two 11.5 foot lanes in each direction and 8.2 foot outside shoulders. The accident rate for this configuration was 1.26 accidents per million vehicle miles. Following the installation of the moveable median barrier, the accident rate increased to 1.52 accidents per million vehicle miles. In the case of the Genvilliers Viaduct, the lanes were reduced from 11.5 feet to 9.8 feet. It should be noted that the traffic and accident statistics are for a period of time shortly after the start up of the moveable median barrier configuration and contemporary statistics are not available because the moveable barrier was later discontinued due to an improvement project which widened the bridge. Therefore, the information concerning the Genvilliers Viaduct is of some, but limited utility.

The Auckland Harbor Bridge has a minimum lane width of 10 feet, the San Diego-Coronado Bridge has a minimum lane width of 12 feet, the Tappan Zee Bridge has a minimum lane width of 11.5 feet, and the Genvilliers Viaduct, during the short period of its existence with a moveable median barrier, had a minimum lane width of 9.8 feet. Only the Genvilliers Viaduct, with 9.8 foot lanes, provides a comparison to the 9 to 9.5 foot lane width proposed for the Golden Gate Bridge. Even this comparison does not provide equal comparison because the Genvilliers Viaduct consisted of four 9.8 foot lanes plus a 12.8 foot center lane and 3.3 foot outside shoulders. This provided a 3.3 foot clear distance for the 9.8 curbed lane, and a 1.5 foot clear distance to the moveable median barrier for the lanes adjacent to the moveable median barrier.

4. Potential effects of above on traffic operations.

a. Effects on traffic flow generally.

Traffic flow on the following four bridges with moveable median barrier installation is analyzed to evaluate the traffic flow on the

Golden Gate Bridge with the installation of a moveable median barrier:

- (1) Auckland Harbor Bridge. Prior to the installation of the moveable median barrier system, this bridge consisted of a through-truss with four 10.5 foot lanes and new bridges attached on both sides of the through-truss consisting of two 12 foot lanes in each direction. This bridge did not have a fixed median barrier. The installation of the moveable median barrier reduced the four central lanes from 10.5 feet wide to 10 feet wide, with the center lanes being operated in a 3/3 and 1/3 configuration. Since the installation of the moveable median barrier in 1990, traffic has increased about 20% and the current ADV is 140,000 vehicles.
- (2) San Diego-Coronado Bridge. This bridge was constructed as a five lane roadway with 12 foot wide interior lanes and 13 foot wide curb lanes. A moveable median barrier was installed for traffic safety. The two foot wide moveable median barrier is moved transversely in a center 14 foot lane, providing a 3/2 configuration of 12 foot wide lanes. The 1995 ADV was 65,000.
- (3) Tappan Zee Bridge. The bridge roadway is seven lanes wide and is operated in a 4/3 lane configuration at all times. All lanes are 11 feet wide. The moveable median barrier was installed for traffic management. In 1996, the ADV was 121,600.
- (4) Genvilliers Viaduct. Prior to the installation of the moveable median barrier, the bridge had a fixed median barrier with two 11.5 foot lanes in each direction and 8.2 foot outside shoulders. After the moveable median barrier installation, there were five lanes consisting of four 9.8 lanes plus a 12.8 foot center reversible lane and 3.3 foot outside shoulders. The moveable median barrier was installed on this bridge for traffic management. The bridge was operated in a 2/3 configuration with a capacity of 115,000 average daily vehicles (ADV)

Two of the above bridges, Genvilliers Viaduct and the Tappan Zee Bridge, installed moveable median barriers for traffic management. Both the Genvilliers Viaduct and the Tappan Zee Bridge had fixed median barriers prior to the installation of the moveable median barrier.

In comparing the effects of a moveable median barrier on traffic flow for the above bridges, it appears that there were no adverse effects. Moveable median barriers were installed on the Genvilliers Viaduct and the Tappan Zee Bridge for traffic management to provide increased directional traffic flow. Both the Auckland Harbor Bridge and the San Diego-Coronado Bridge experienced increases in traffic volume following the installation of a moveable median barrier. It should be noted, however, that all of the above bridges have lane widths in excess of the lane width proposed for the Golden Gate Bridge, and that there are no available statistics on the effects on traffic flow in a 9.5 foot wide lane adjacent to a 32 inch high barrier.

b. Effects on bus and truck operations.

Truck and bus traffic on the Golden Gate Bridge is approximately 3.1% of the total traffic. This represents approximately 3,500 trips per day. District buses are eight feet six inches wide without mirrors, and ten feet four inches wide with the mirrors. Buses are 40-45 feet long. The widths of large trucks are similar to those of buses. The legal lengths of trucks can be up to 68 feet. In addition, trucks and buses actually occupy a wider sweep path as they travel around curves due to the length of vehicle and the off-tracking of the rear wheels. The actual sweep path for a District bus adds one foot to the effective width of a bus. A District bus, even if steered precisely down the center of the lane, does not fit within a ten foot lane without encroachment over the lane lines. The Northwestern Traffic Safety Study recommended 11 foot lane widths on the Golden Gate Bridge to allow for large vehicle off-tracking in curves, minor variations in lane positioning, and possible lateral movement due to wind gusts.

C. ISSUES RELATING TO LOSS OF SIGHT DISTANCE.

1. Effect of higher brake warning lights on vehicles since 1985.

The AASHTO code specifies the minimum stopping sight distance required for a vehicle traveling at a specified speed to stop before reaching a stationary object in the roadway. The standard criteria for applying this code is to measure the available sight distance from the driver's eye

height to an object six inches in height which is centered in the lane. The present available stopping sight distance for a vehicle traveling 45 to 50 miles per hour on the Golden Gate Bridge San Francisco approach curve (a 1,000 foot horizontal curve with a cross slope of 4% and a longitudinal slope of 3%) and the Golden Gate Bridge Marin approach curve (horizontal curve with a radius of 1,075 feet, cross slope 3.7%, and a longitudinal slope of 2%), is 430 feet. The installation of a moveable median barrier on the north and south curves of the Golden Gate Bridge reduces the available stopping sight distance to approximately 220 feet. The available stopping sight distances for the Auckland Harbor Bridge, Tappan Zee Bridge, and the San Diego-Coronado Bridge were compromised by the installation of a moveable median barrier; however the reduction in the stopping sight is less than that proposed for the Golden Gate Bridge. The overall accident rates on the Auckland Harbor Bridge, Tappan Zee Bridge, and San Diego-Coronado Bridge do not indicate that the reduction in the available stopping sight distance became a major contributor to the accident rate. The effect of higher brake warning lights on vehicles since 1985 may mitigate the loss of available stopping sight distance.

There are two aspects concerning the reduction in the available stopping sight distance due to the installation of a moveable median barrier to consider:

- a. The speed limit on the Golden Gate Bridge is currently set at 45 miles per hour with actual median speeds in excess of 50 miles per hour.

The available sight distance of 220 feet with a moveable median barrier is equivalent to a design speed for approximately 35 miles per hour. It is anticipated that vehicles in the lane adjacent to the moveable median barrier will travel 45-50+ miles per hour with the traffic flow, thereby further reducing their ability to stop due to reduced stopping sight distance.

- b. Although the AASHTO criteria specifies an object of six inches in height be used to evaluate stopping sight distance, a 32 inch high moveable median barrier would actually obstruct the driver's vision of objects in the road as high as 28 inches. An object 28 inches high could include a downed motorcycle and rider, cargo dropped from another vehicle, and vehicle components such as wheels, bumpers, or mufflers.

IV. CONCLUSION

In the final analysis, there is no single clear-cut answer to the question of whether the one foot wide moveable median barrier should be installed on the Golden Gate Bridge. As Professor Seyfried of the Northwestern University Traffic Institute concluded, the decision is essentially a virtual toss-up, and the Board could reasonably make a decision either way.² The final decision must result from a balancing of factors and considerations which in turn will require the Board to determine which considerations and factors are most important. For a summary of four bridges with moveable median barriers and the proposed moveable median barrier for the Golden Gate Bridge, see Attachment A.

Some things are known. For example: The safety record on the Golden Gate Bridge in terms of total accidents is actually better than that of California roadways, including freeways with medians and median barriers, and, in terms of fatal and injury accidents is better than similar undivided roadways and essentially equal to divided freeways. In the 1991-1995 period, accident rates on the Golden Gate Bridge have been reduced by about one half, and fatal and injury accidents have declined as an absolute number although the percentage of such accidents compared to the reduced number of total accidents has increased. The total accident rates on the Golden Gate Bridge are still lower than those on the Auckland, New Zealand Bridge and the San Diego-Coronado Bridge after installation of

²Caltrans has reviewed the Northwestern study of November 17, 1997. Caltrans' response, dated February 24, 1998 (Attachment B) does not reach a firm conclusion either way, indicates that Caltrans shares the safety concerns expressed in the Northwestern report, and comments that actual performance of such a barrier, if installed, and its effect on average speeds, the number and types of accidents, and the impact of restricted stopping sight distance are difficult to predict, determine, or assess. Caltrans does point particularly to the importance of anchoring end sections, particularly at the south end of the Bridge and of the type of attenuators to be placed. Accordingly, if the District Board determined to install the barrier, Caltrans suggests installation on a trial basis. In a separate letter, also dated February 24, 1998 (Attachment C), Caltrans has indicated that if the Golden Gate Bridge, Highway and Transportation District decided to install a moveable median barrier on the Golden Gate Bridge, Caltrans would propose to install a similar one on Doyle Drive. However, Caltrans indicated that such installation would be predicated on a widening of Doyle Drive and its structures, entailing possibly several years of study, coordination with the current study being conducted by the San Francisco County Planning Authority, and resolution of issues of funding, seismic design, and environmental concerns. Caltrans could, therefore, give no definitive time frame.

two foot moveable median barriers on those bridges and the accident rates involving injury and death compare favorably to these bridges. Nonetheless, cross-over accidents have continued to occur sporadically from time to time, and they are generally more severe in terms of injuries and deaths. Installation of the one foot wide moveable median barrier would, presumably, eliminate such cross-over accidents.

Other things are less clear and involve some risk. Experience on the Auckland, New Zealand and the San Diego-Coronado Bridges shows not only a decline in fatal and injury accidents, but a decline in total accidents as well - a result contrary to that predicted in the 1985 Northwestern study and to Caltrans studies and one characterized by Northwestern as "counter-intuitive," but nonetheless a result that did occur on those facilities. While these results suggest the same might occur on the Golden Gate Bridge, nonetheless, because of the unique physical conditions and limitations of the Golden Gate Bridge (which would have the narrowest lanes and greatest reduction of stopping sight distance upon installation of a barrier), it cannot be stated with certainty that the same result would prevail. The same is true of traffic capacity. The experience at the San Diego-Coronado and Auckland Bridges is that barrier installation has had no adverse impacts on traffic flow and that actual increases in traffic volumes were experienced. It is not clear that the same would necessarily occur on the Golden Gate Bridge upon installation of a barrier because of its unique physical conditions and limitations; it might and it might not.

The actual effect of the reduction of lane widths on traffic capacity and traffic flow likewise cannot be predicted with certainty. No proposed configuration is ideal or meets all criteria, but the compromise proposed probably best accommodates the needs of bus and truck traffic in outer lanes and provides for the widest lanes feasible adjacent to the barrier, given the narrow width of the roadway. As indicated, experience in San Diego and Auckland do suggest no adverse impacts on traffic capacity and flow, albeit in less limiting physical circumstances.

The effect of the barrier as a cause of accidents is likewise difficult to predict with certainty. There is certainly a risk of accidents in the same direction of traffic caused by vehicles striking and rebounding off the barrier, as well as accidents which may occur in opposing traffic lanes on the other side of the barrier resulting from deflection of the barrier if struck. The proposed one foot barrier's maximum deflection of 32 inches in crash testing with high speed, larger vehicle impacts, while perhaps not ideal, is a decided improvement over deflections experienced with the older, two foot barrier both in crash tests and actual experience. The maximum deflection would likely occur only in relatively infrequent occurrences. The fact that such accidents have not been a major problem on the other bridges studied is

comforting, but the more favorable physical conditions prevailing on those bridges must also be taken into account.

In reaching its recommendation, staff has also given consideration to the beneficial results stemming from the 45 mile per hour speed limit, legislative imposition of the double fine zone, increased enforcement efforts, public education and warnings and the implementation of the use of LIDAR on the Bridge, and to the cost and funding of other safety projects such as the seismic retrofitting of the Bridge and the public safety rail.

While the answer is far from clear cut, after weighing and balancing all the factors, the benefits, the risks and detriments, both known and unknown, staff recommends that the Board of Directors conceptually approve installation on the Golden Gate Bridge of the one foot wide moveable median barrier developed by Barrier Systems, Inc. In the thirteen years since the Board considered the issues of installation of a moveable median barrier, successful installation of such barriers have occurred at other major bridges with favorable results. While these results are more problematical respecting the Golden Gate Bridge because of its unique physical characteristics, and there are certainly negative tradeoffs arising from narrower lane widths, reduced sight distance, loss of raised lane markers, issues concerning emergency vehicle response, and the possibility of barrier-caused accidents, and while reasonable minds might resolve the tradeoffs differently, staff has concluded that, on balance, the virtual elimination of cross-over accidents which tend to result in more serious injuries or deaths, outweighs the detriments and potential unknown or uncertain risks mentioned above, and tips the scale in favor of installation of the barrier.

Of course, even if the Board gives conceptual approval, accurate costs of installation must be finalized, necessary permits and authorizations must be obtained, funding sources must be identified and funding procured, and acceptable solutions must be found to those issues which must be resolved even after the conceptual decision is made. These issues, as identified in the District Engineer's January 16, 1998 Status Report to the Committee of the Whole, are summarized at pages 10 and 11 of the attached Appendix A. And once the barrier is installed, its functionality and operational characteristics, its effect on traffic flow, safety, and emergency vehicle response, and maintenance and operational costs must be carefully and periodically monitored and evaluated.

Following conceptual approval, should it occur, the following tasks must be satisfactorily completed before installation of the moveable median barrier on the Golden Gate Bridge:

GGBHTD/GGNRA Toll Plaza Planning. The District is currently meeting with GGNRA concerning joint planning of the toll plaza

for conformance with the Presidio Plan. Design of the transfer vehicle storage and maintenance building cannot proceed until this planning component is completed.³

Obtain NPS Permit: The Golden Gate Bridge and its facilities are within the National Park boundaries and, therefore, are subject to NPS permit requirements.

Caltrans' Review and Concurrence. Caltrans' review and concurrence is required in a number of areas for this project: Funding - Caltrans is designated the certifying agency for federal highway funds, if federal funds are to be sought; Highway 101 - Caltrans is the approving agency for changes and modifications to Highway 101; North End Transfer Vehicle Storage - approval and easement required to store transfer vehicles in the Caltrans median at the north end; Doyle Drive Continuity - Caltrans concurrence to assure continuity of barrier system with Doyle Drive.

Obtain Funding. This project is included in the Capital Budget (100% District); however, the District may want to seek federal funding (BESTEA) which will require historic and area evaluation in accordance with Section 106, and environmental impact analyses in accordance with NEPA. Moreover, final design could not start until the completion of the environmental impact analyses.

Emergency Response Plan. Procedures for emergency vehicle response must be developed to respond to Bridge emergencies with the barrier in place.

Award Contract for Design. Advertise, select, and award professional services design contract in accordance with District procedures, to encompass:

Historic and Area Evaluation. The Golden Gate Bridge is eligible for the National Register of Historic Places and must be evaluated in accordance with Section 106 criteria.

Environmental Impact. Compliance with the California Environmental Quality Act will be required. Compliance with the National Environmental Policy Act will also be required if federal funds are sought and document must be completed prior to the start of the design.

Lane Markings. The moveable median barrier system would require the removal of the existing ceramic lane markers. New lane markers compatible with the moveable barrier system must be developed and tested.

³Staff notes that consideration is being given to use of a reversible lane configuration on U.S. 101 through San Rafael, which might afford some opportunities for interagency cooperation.

Lateral Positioning of the Moveable Median Barrier. Final determination and evaluation must be made on the most effective lane configuration for traffic and District operations.

Anchorage System. Anchor design and connection to the end cushioning system in the toll plaza area must be developed.

Transfer Vehicle Storage and Maintenance Facility Design. Design of the storage and maintenance building is contingent upon completing the joint GGBHTD/GGNRA toll plaza planning and environmental report in accordance with the GGNRA timetable to do this.

Negotiate Sole Source Cost with BSI. Barrier Systems, Inc., is the patent holder for the Quick-Change Barrier System and as such is the sole source. Therefore, the contract with BSI must be negotiated and finalized.

Fabricate Transfer Vehicles and Barrier. Upon the negotiation of a cost with BSI, two transfer vehicles and approximately 10,000 linear feet of barrier must be fabricated.

Construct Transfer Vehicle Storage/Maintenance Building. Advertise for construction bids, award construction contract, and construct facility.

Install Lane Markers, Anchors, and Guidance System. Advertise for construction bids, award contract, and install.

Test Transfer Vehicles. Test transfer vehicles and guidance system at the site to assure reliability.

Install System. Deliver barrier system to the site and place it in a 3-3 lane configuration over a period of minimal traffic activity.

The preliminary estimated schedule for implementation, as indicated in Section II of this Report, is approximately 24 to 38 months. According to preliminary estimates from GGNRA, thirteen (13) months of the time period is required for the joint GGBHTD/GGNRA toll plaza planning necessary for the design and construction of the Transfer Vehicle Storage/Maintenance Building. The thirteen (13) month planning period is specified in the Comprehensive Plan for the Golden Gate Bridge Toll Plaza Area developed by the National Park Service. Upon completion of the planning process, a permit from the National Park Service must be obtained. Staff hopes that the permit would be issued relatively shortly after completion of the planning process. The timing of GGNRA activity is beyond staff's control. However, staff would use its best efforts to expedite those processes. Moreover, upon conceptual approval, staff will initiate negotiations with the National Park Service for possible interim facilities for the storage/maintenance of the transfer vehicles.

RECOMMENDATION

The Committee recommends that the Board authorize conceptual approval for the installation of the Barrier System, Inc., one-foot moveable median barrier on the Golden Gate Bridge; and, authorize staff to finalize accurate costs of installation, obtain necessary permits and authorization, identify and procure funding sources, and develop acceptable solutions to the items specified in this report which must be resolved after the conceptual decision is made.

MCG/ke

Attachments: Attachment A, Summary of Moveable Median
 Barriers on Bridges
 Attachment B, Caltrans Letter
 Attachment C, Caltrans Letter
 Appendix A, Background Summary

	MOVEABLE MEDIAN BARRIER (MMB)				PROPOSED MMB	
	Genvilliers Viaduct	Auckland Harbor Bridge	Tappan Zee Bridge	San Diego-Coronado Bridge	Golden Gate Bridge	
Number of Lanes	5	8	7	5	6	6
Lane Configuration					Present Configuration	Configuration A
Peak Hour	2/3	3/5	4/3	2/3	4/2	4/2
Non-Peak Hour	2/3	4/4	3/3	2/3	2/1/3	3/3
Min. Lane Width (ft)	9.8	10	11.5	12	10	9.5
Max. Lane Width (ft)	9.8	12	11.5	12	11	11
Shy Distance at Curb - Peak (ft)	3.3	0*	0.5	0	0	0
Shy Distance at Barrier - Peak (ft)	1.5	0	0.25	0	0	0
Shy Distance at Curb - Non-Peak (ft)	3.3	0*	0.5	0	0	0
Shy Distance at Barrier - Non-Peak (ft)	1.5	0	6.0	0	0	0
Min. Curve Radius (ft)	2,135	1,100	?	1,800	1,000	1,000
Min. Stopping Sight Distance - Required (ft)	275	336	500	430	360	360
Min. Stopping Sight Distance - Actual (ft)	310	250	—	300	220	220
Speed Limit (mph)	37	43	55	50	45	45
Average Daily Traffic	115,000	140,000	121,600	65,000	117,000	
Injury and Fatal Accidents per Million Vehicle Miles (MVM)	0.50	0.32	?	0.23	0.31	
Total Accidents per MVM	1.52	1.61	?	0.71	0.61	—

*Occurs only in the 3,220 foot truss bridge. The 1,600 foot approach bridges on each end of the truss bridge have raised medians.

DEPARTMENT OF TRANSPORTATION

BOX 23660

OAKLAND, CA 94623-0660

(510) 286-4444



February 24, 1998

Mr. Mervin C. Giacomini (N)
Golden Gate Bridge, Highway and
Transportation District
P.O.Box 9000 Presidio Station
San Francisco, CA 94129-0601

Dear Mr. Giacomini:

Thank you for forwarding copies of the Northwestern University Traffic Institute Moveable Median Barrier Traffic Safety Study on November 17, 1997.

Caltrans District 4 and Headquarters staff have reviewed the draft report dated October 29, 1997. We share the same safety concerns as expressed in the report.

It is very difficult to predict how the barrier will actually perform on the existing bridge alignment and lane configurations as we cannot predict how the motorists will react to its presence on the highway. Whether the average speeds, the number and types of accidents will change with the presence of the barrier and the narrower lane widths is difficult to determine.

The anchoring of the end section, particularly on the south end, as well as the type of end attenuator to be placed are very critical on how well the barrier will perform and types of accidents that will occur.

It is also very difficult to assess precisely what the impact of the restricted stopping sight distance will have on the number and types of accidents that will occur. Due to the above concerns, a trial installation may be a possible alternative in order to quantify the impacts of a barrier on the bridge. Should the Bridge District decide to install the moveable median barrier on a trial basis, Caltrans is willing to cooperate and share our expertise on it's installation

Sincerely,

HARRY Y. YAHATA
District Director

By: 

H. P. HENSLEY
Chief Deputy District Director

RECEIVED

FEB 25 1998

GOLDEN GATE BRIDGE
ENGINEERING DEPARTMENT

SCANNED

Date: 3/5

Initials: KME


2.1.10.1f.1

DEPARTMENT OF TRANSPORTATION

BOX 23660
OAKLAND, CA 94623-0660
(510) 286-4444
TDD (510) 286-4454



February 24, 1998

Mr. Mervin C. Giacomini 
Golden Gate Bridge, Highway and
Transportation District
Box 9000, Presidio Station
San Francisco, CA 94129-0601

SF/Mm-101
Golden Gate Bridge

Dear : Mr. Giacomini,

This letter is in response to your letter of January 22, 1998. You asked the question "If the District decided to install a moveable median barrier on the Golden Gate Bridge, would Caltrans also install a moveable median barrier on Doyle Drive and, if so, what would be the time frame for that installation."

If a decision were made by the GGBHTD to install a moveable median barrier on the Golden Gate Bridge, Caltrans would also propose a project to install a similar barrier on the contiguous Doyle Drive portion of the highway. However, we will need to initiate a project to widen the highway and structures first so that a barrier could be placed. As you are aware, Doyle Drive is only 60 feet wide, which is less than the 62 feet on the Golden Gate Bridge. This structure widening project may take several years of study based on our previous experience on widening Doyle Drive, as it will need to be coordinated with the study currently being undertaken by the San Francisco County Transportation Authority to determine the future configuration of Doyle Drive. Funding and a seismic design review for this widening project will also be major issues that will need to be resolved as well. The widening of the Doyle Drive structures may also raise environmental concerns that may require the agreement of many diverse groups including local, state and federal agencies, especially in light of the environmental studies for the future of Doyle Drive.

At this time, we cannot give you a definitive time frame as to when we could install a moveable median barrier on Doyle Drive if the Golden Gate Bridge District should decide to install a movable barrier on the Golden Gate Bridge.

Sincerely,

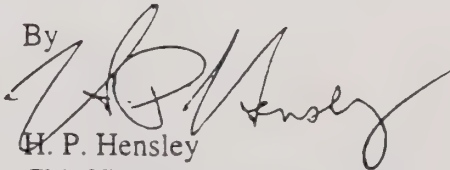
RECEIVED

FEB 25 1998

GOLDEN GATE BRIDGE
ENGINEERING DEPARTMENT

bcc: HYahata
HPHensley
JSMcCrank
HMorimoto
HBenour, HQ Traffic Operations
RPeter, ESC/Trans Lab

HARRY Y. YAHATA
District Director

By 
H. P. Hensley
Chief Deputy District Director

SCANNED	
Date:	3/4
Initials:	Kme

2.1.10.15.1



AGENDA ITEM 2
GOLDEN GATE BRIDGE, HIGHWAY AND TRANSPORTATION DISTRICT

MERVIN C. GIACOMINI, P.E.

DISTRICT ENGINEER

Jan 13, 1998

For: Jan 16, 1998

TO: Committee of the Whole
FROM: Mervin C. Giacomini, District Engineer
SUBJECT: GOLDEN GATE BRIDGE, MOVEABLE MEDIAN BARRIER -
STATUS REPORT (INFORMATION)

I. INTRODUCTION

The various studies and tests authorized by the Board pertaining to the consideration of a moveable median barrier for possible application on the Golden Gate Bridge have now been completed. The E-TECH Crash Test Report, AutoDesk Demonstration, and Northwestern University Traffic Institute Traffic Safety Study were presented at the December 5, 1997 meeting of the Building and Operating Committee. A summary of the Northwestern University Traffic Safety Study and the AutoDesk demonstration were presented at the December 19, 1997 meeting of the Board of Directors. Consequently, the District is now in a position to start the process of reviewing and analyzing the results of these studies and tests. This report provides background information regarding the work performed to date, including the December Building and Operating Committee and Board meetings (Section II), the information requested at the December 19, 1997 meeting of the Board of Directors (Section III), issues requiring further study (Section IV), and a proposed process for the discussions regarding the moveable median barrier at future meetings of the Committee (Section V).

In addition to the staff presentation to the Committee of the Whole on January 16, Barrier Systems, Inc. (BSI), will make a presentation on their technology and address questions by District Directors.

II. BACKGROUND

Barrier Development and Testing

BSI completed the development and fabrication of approximately one hundred feet of the one-foot moveable median barrier for testing. They conducted a public demonstration of their barrier, including crash testing on January 8, 1997 at the Rio Vista airport. Some Board members and staff attended the demonstration.

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Certification Testing

The Board, by Resolution No. 96-161, authorized District's participation in the cost, not to exceed \$42,500, of certification testing the moveable median barrier by Barrier Systems, Inc. pursuant to the National Cooperative Highway Research Program (NCHRP) Report No. 350. Staff negotiated a fee of \$32,450 with E-TECH Testing Services, Inc., of Lincoln, CA, to perform the NCRP 350 certification testing at their Lincoln test facility. Crash testing was conducted March 26, 1997, using a small car with a nominal weight of 1,800 lbs. at a speed of 62 mph and an approach angle of 20 degrees. On March 27, 1997, crash testing was conducted using a pickup truck with a nominal weight of 4,400 lbs., at a speed of 62 mph and an approach angle of 25 degrees. The barrier deflected approximately 18 inches in the small car crash and approximately 32 inches in the pickup truck crash. E-TECH Testing Services submitted the final test reports to the District the first of May.

The draft test report has been reviewed by the District, Northwestern University Traffic Institute (Northwestern), and Caltrans. E-TECH has responded to the review comments. Staff and Caltrans have accepted the report as complete and the Federal Highway Administration (FHWA) has approved the crash test report. District Engineer Mervin C. Giacomini briefly summarized the E-TECH Final Report of May, 1997 at the December 5, 1997 meeting of the Building and Operating Committee.

Barrier Analysis and Traffic Engineering

The Board, by Resolution No. 96-161, authorized the General Manager to expend up to \$50,000 to engage Northwestern and, if deemed necessary or appropriate, additional traffic engineering and safety consultants, to evaluate and make appropriate recommendations to the Board of Directors pertaining to BSI's proposed resolution of certain technical issues raised by the District Engineer, and to evaluate and make recommendations to the Board of Directors concerning traffic, operational, and safety tradeoffs between installation of such barrier and the operation of the Bridge without the barrier.

Northwestern was issued a Notice to Proceed effective September 12, 1996, for the first phase of the work in the amount of \$25,000. Northwestern developed criteria in March for barrier performance on the Golden Gate Bridge, analyzed the risk of a barrier system deflecting into oncoming traffic, and analyzed traffic data and prepared conclusions based on deflection characteristics determined by crash testing, with

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respect to the one-foot moveable median barrier impact on traffic flow, safety, and capacity. Northwestern submitted a report to the District, "Traffic Safety Study for Moveable Median Barrier System on Golden Gate Bridge," dated October 29, 1997, which was distributed to members of the Board of Directors November 14, 1997.

Building and Operating Committee Meeting of December 5, 1997

At the December 5, 1997 meeting of the Building and Operating Committee, Mr. Robert K. Seyfried, Director of Transportation Engineering Division, Northwestern University Traffic Institute, presented a 50 minute summary review of the Northwestern University Traffic Institute Traffic Safety Study Report.

Mr. Seyfried's presentation included the following:

- A summary of the changes which have occurred since the Northwestern 1985 study.
- Accident experience in the 1991-95 period, noting, among other things, a reduction of accident rates by about one half since 1985 and a rate significantly lower than the average rate for California roadways, including freeways, and a decline of fatal and injury accidents, but an increase in the percentage of such accidents compared to total accidents.
- Review of experience at other installations of the two foot wide barrier, namely the Genvilliers Viaduct outside Paris, France (no longer in use), the Auckland Harbor Bridge in New Zealand, the San Diego/Coronado Bridge and the Tappan Zee Bridge in the state of New York.
- Barrier performance criteria, including a discussion of a mathematical model.
- A rebound and deflection analysis, noting that the narrow moveable median barrier performed significantly better than the two foot barrier in terms of deflection and rebound angle.
- A discussion of end treatment issues, particularly at the San Francisco end of the Golden Gate Bridge.
- A discussion of stopping sight distance issues and considerations.
- A discussion of lane width and barrier positioning issues and the desirable criteria therefor, noting that no

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single lane configuration studied satisfied all criteria, and that the District staff would have to weigh various alternatives.

- A discussion of emergency vehicle access issues which must be considered.
- A discussion of a cost-benefit analysis he conducted.

Mr. Seyfried briefly referred to some of the potential positive and negative impacts which could result from installation of a moveable median barrier. Mr. Seyfried concluded that, in view of the various factors which must be weighed, he could not come up with a final recommendation, that the final decision was up to the Board, and that he viewed the decision as a virtual toss-up. He stated that the Board could reasonably make a decision either to install or not install a moveable median barrier.

Mr. Seyfried stated that if the decision was to install the moveable median barrier, a number of issues had to be resolved, including:

- Lateral positioning of the barrier.
- Development of an anchorage system for the terminal end of the barrier at the toll plaza.
- Development of a guidance system compatible with the Bridge and Bridge deck.
- Development of operating procedures for emergency vehicles.
- Design of transfer vehicles and the location and design of storage facilities.

Mr. Seyfried also said that, if the decision was to install a moveable median barrier, he recommended a two to three year trial period, if feasible, and, in any event, a monitoring program covering accident frequency and severity, barrier impact frequency and the magnitude of barrier displacement, secondary impacts, emergency vehicle response, and operating and maintenance costs.

After Mr. Seyfried's presentation, there were a number of questions from the Board members.

1. Director Boro asked if installation of a moveable median barrier might constitute a permanent presence which might change driver behavior. Mr. Seyfried stated that was a

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possibility and added that it was hard to say why total accident frequency declined in other installations.

2. Director Harberson questioned the comparability of the San Diego/Coronado Bridge as it is wider and carries less traffic. He also noted that the District buses ranged from 9 feet 8 inches, to 10 feet 2 inches in width.
3. Director Simms asked if Northwestern was able to evaluate 9 foot lanes. Mr. Seyfried noted that the Auckland Harbor Bridge must have 9 foot lanes as it is 40 feet wide and a two foot barrier is used there.
4. Chair McDonnell inquired as to whether sight distances are mandated by FHWA. Mr. Seyfried said that there are standards for new construction. Chair McDonnell asked what the design immunity implications were. Attorney David J. Miller stated that the Board would have to balance all relevant factors and that no one factor would deprive the District of design immunity. Mr. Seyfried commented that design exceptions are not unusual and the question was whether the benefits outweigh the costs.
5. Director Eddie asked if Northwestern had analyzed the matter of the length of trucks going around curves on the Bridge. Mr. Seyfried stated that in general the longer the truck the more "off track" it would be, but that Northwestern did not analyze that particular issue; however it did analyze the issue with reference to buses and determined that their width on curves would be about one foot wider than their actual width.
6. Chair McDonnell noted that if the percentage probabilities of rebound and second deflection accidents were added, there would be a 45 percent probability of some additional accident.
7. Chair McDonnell also said he felt the typical driver reaction on impact with the barrier would be to veer away from it. Mr. Seyfried said that, because of possible damage to the vehicle upon an impact and the physical displacement of the driver's position, he felt driver control was less likely to be a factor.

Board Meeting of December 19, 1997

At the December 19, 1997 meeting of the Board of Directors, the District Engineer presented a 30 minute review of the Northwestern University Traffic Institute Report, "Traffic Safety Study for a Moveable Median Barrier System on the Golden Gate Bridge," dated October 29, 1997. He responded to

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a number of questions from the Board members regarding lane width and barrier positioning issues, accident rates, and enforcement of the speed limit. President Fraser concluded the Board review and advised that further consideration of this project would be scheduled for the meeting of the Committee of the Whole on Friday, January 16, 1998.

Caltrans Participation

Caltrans and the District signed a Letter of Intent, December 31, 1996 for Caltrans' assistance in the evaluation and development of a moveable median barrier for the Golden Gate Bridge. Caltrans reviewed and concurred with the E-TECH NCHRP crash testing report and is currently reviewing the Northwestern Traffic Safety Study. It is anticipated that the Caltrans review comments and recommendation will be received prior to the January 16, 1998 meeting of the Committee of the Whole.

AutoDesk Project

Several of the traffic lane configurations using the one-foot wide moveable median barrier result in lane widths under ten feet wide. There is little historic data available to analyze the behavior of motorists driving in narrow lanes adjacent to a barrier with no space between the edge of the lane line and the barrier. The District Engineer discussed this problem with AutoDesk who agreed, as a public service in order to assist the District in analyzing this complex situation, to develop 3-D visualization of a car driving across the Golden Gate Bridge in the lane adjacent to the barrier and passing the moveable barrier transfer vehicle. At the December 5, 1997 Building and Operating Committee meeting and the December 19, 1997 meeting of the Board, the District Engineer presented the AutoDesk video depicting a computerized visualization of a car driving the Golden Gate Bridge with the moveable median barrier in place.

III. INFORMATION REQUESTED AT DECEMBER 19, 1997 BOARD OF DIRECTORS MEETING

1. Director Kaufman requested information on the comparison of the moveable median barrier installed on the Genvilliers Viaduct near Paris to the application of a moveable median barrier on the Golden Gate Bridge.

Staff Response: The five-lane Genvilliers Viaduct near Paris, France, prior to installation of the moveable barrier system in 1986, had a fixed median barrier with two 11.5 feet lanes in each direction and 8.2 feet outside shoulders. After the moveable barrier

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installation, there were four 9.8 feet lanes plus a 12.8 feet center reversible lane with 3.3 feet outside shoulders. The roadway carried 115,000 vehicles per day.

The facility was evaluated in a Northwestern University Traffic Institute report in 1987 (available in the District Engineer's office) which concluded that in the four months following installation of the moveable median barrier system the accident rate increased from 1.26 accidents per million vehicle miles to 1.52 accidents per million vehicle miles. Injury accidents increased from 19% to 33% of the total accidents. Barrier system displacements up to 3.9 feet were observed on the Genvilliers Viaduct barrier. No secondary impacts due to barrier displacement were identified. The use of the moveable median barrier system was later discontinued due to an improvement project which widened the viaduct.

The Genvilliers Viaduct utilizing a moveable median barrier in the center lane functioned in a 2-3 configuration with minimum lane widths of 9.8 feet. The minimum lane proposed for the Golden Gate Bridge is 9.0 feet. The Genvilliers viaduct operated at an average daily traffic volume of 115,000 vehicles per day, roughly equivalent to the Golden Gate Bridge average daily traffic volume in 1997 of 116,000 vehicles per day. The accident rate of 1.52 accidents per million vehicle miles for the Genvilliers Viaduct with a moveable median barrier exceeds the present accident rate of 0.64 accidents per million vehicle miles on the Golden Gate Bridge without a moveable median barrier.

2. Director Kaufman requested information on a determination of the proposed lane configuration for the Golden Gate Bridge with a moveable median barrier.

Staff Response: The Northwestern Traffic Safety Study analyzed eight different lane configurations with a moveable median barrier in the 3-3 configuration and in the 2-4 configuration. The criteria for evaluating the eight configurations was as follows:

- All lanes should be at least ten feet wide and in no case should any lane be less than nine feet wide.
- The outside lanes (curb lanes) should remain eleven feet wide.
- The lanes adjacent to a moveable median barrier system should be as wide as possible.

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- When the roadway is in the 2-4 configuration, the two lane section should be more than twenty feet wide.

None of the analyzed alternatives completely satisfied all the lane width criteria. Although Alternate "E" best satisfies the criteria, the alternates will be reviewed by staff based on the relevant importance of the various lane width criteria to determine the scheme which best meets the needs of the District. The following describes Alternate "E" in various configurations: a) The 3-3 configuration: the number one lane, adjacent to the barrier, is 10 feet; the number two lane is 9.5 feet; and, the number three lane, the curb lane, is 11 feet. b) The 2-4 configuration: in the two lane section the number one lane, adjacent to the barrier, is 10 feet and the number two lane, adjacent to the curb, is 11 feet. For the four lane section, the number one lane, adjacent to the barrier, is 9 feet, the number two lane is 10.5 feet, the number three lane is 9.5 feet, and the number four lane, adjacent to the curb, is 11 feet. The raised ceramic lane markers along the lane lines interfere with the placement of the moveable median barrier in all eight alternatives. In addition, when the barrier is deflected by a crash, the ceramic lane markers will be disengaged from the roadway. The feasibility of replacing ceramic lane markers along the lane lines will be evaluated as part of the evaluation of alternate barrier configurations.

3. Director Kress requested information regarding the correlation between speed control on the Golden Gate Bridge and the prevention of accidents.

Staff Response: Recent accident statistics set forth below suggest a direct correlation between speed and number of accidents. For instance, in 1995 there were a total of 54 accidents. In 1997, the first full year after implementation of the double fine zone, vans noting the 45 mile per hour speed limit and double fine zone patrolling the Bridge, and the use of LIDAR by the CHP, there were 22 total accidents, a 59% reduction in the number of accidents. Likewise, a primary comparison of statistics for the same two years does not suggest that speed control might have a correlation of a lower number of cross-over accidents. However, to confirm these apparent correlations, studies over a longer period would probably be helpful and the raw statistics may need to be refined.

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4. Director Middlebrook requested information concerning the current accident rate.

Staff Response: The Northwestern University Traffic Safety Study used accident statistics on the Bridge for the years 1991 through 1995. The inclusion of statistics for 1996 and 1997 results in a slight reduction in the total accident rate from 0.64 accidents per million vehicle miles to 0.61 accidents per million vehicle miles.

YEAR	TOTAL ACCIDENTS	INJURY ACCIDENTS	FATAL ACCIDENTS	PROPERTY DAMAGE ACCIDENTS	CROSS-OVER ACCIDENTS
1991	35	18	0	17	3
1992	53	22	0	31	5
1993	46	17	0	29	6
1994	42	17	3	22	6
1995	54	28	0	26	4
1996	46	39	1	7	7
1997	22	15	0	7	5
TOTAL	298	156	4	139	36
PERCENT	100%	52%	1%	47	12%
RATE (/MVM)	0.61	0.3	0.01	0.28	0.07

The double fine zone was implemented in September, 1996 with signs at either end of the Bridge. Two vans with signs noting the 45 mph speed limit and double fine zone were placed in operation late October 1996. The California Highway Patrol started using LIDAR in July 1997. The accident rates for 1997 are for the one year period in which all three of the traffic controls were in effect.

YEAR	TOTAL ACCIDENTS	INJURY ACCIDENTS	FATAL ACCIDENTS	PROPERTY DAMAGE ACCIDENTS	CROSS-OVER ACCIDENTS
1997	22	15	0	7	5
PERCENT	100%	68%	0	32%	23%
RATE (/MVM)	0.31	0.22	0.00	0.10	0.07

IV. ISSUES REQUIRING FURTHER STUDY

1. Lateral Positioning of the Barrier System. Several alternative barrier positioning schemes were evaluated in the Northwestern study. None is fully satisfactory in terms of desired lane widths. Staff will review these alternatives based on the relative importance of the various lane width criteria to determine what scheme on balance might best meet the needs of the District if a moveable median barrier were installed. The feasibility and advisability of replacing raised ceramic lane markers along the lane lines with flush or recessed markings will be evaluated in the evaluation of alternative barrier configurations.
2. Anchorage for the San Francisco End of the Barrier System. Satisfactory functioning of the barrier system and crash cushion at the San Francisco end requires the development of an anchorage system. Although such an anchorage appears at least at this point to be technically feasible, it must be designed and tested before a moveable median barrier system can be installed.
3. Guidance System for the Barrier Transfer Vehicle. Because of the relatively narrow lanes and the possible need to locate a barrier system with its base adjacent to or straddling the raised pavement markers on the Bridge, precise placement of the barrier system is important. A guidance system which assures consistent, accurate placement of the barrier system as it is moved from one position to another must be designed and tested.
4. Procedures for Emergency Vehicle Response. In conjunction with emergency vehicle operating agencies, strategies must be developed for responding quickly and effectively to accidents on the Bridge, depending on lane configurations. Of particular concern is the development strategies for accessing the accident site, removing stalled or damaged vehicles, and relocating the barrier system if it has been displaced by the accident. Specialized equipment such as double-ended tow trucks may need to be acquired.
5. Moveable Median Barrier Transfer Vehicle Storage and Maintenance Facilities. The location and requirements for moveable median barrier transfer vehicle storage and maintenance facilities must be defined.

Previously received cost figures from BSI may not be current and did not include all items of cost to the

Committee of the Whole Item No. 2 for January 16, 1998/Page 11

District should it decide to install a moveable median barrier.

6. Project Costs. Costs for the barrier; transfer vehicles, including lease or buy-back, and associated components; cost of possible special equipment, such as double-ended tow trucks (if required); lane line reconfiguration; end anchorage; guidance system; emergency response equipment; annual maintenance, operation and repair costs; and, transfer vehicle storage and maintenance facilities must be developed. Staff has scheduled a meeting on January 9, 1997 with BSI to develop preliminary costs for these items.

V. RECOMMENDED PROCESS

A press release was issued noticing the December 5, 1997 meeting, and advising that the Traffic Safety Study report is available at the District Secretary's Office and specified public libraries.

The magnitude and complexity of the application of a moveable median barrier on the Golden Gate Bridge necessitate that the process be one that is clear and concise, and provide ample opportunity for input from the consultants, the public, and Board members. The Crash Test Report by E-TECH Testing Services, Inc., and the Traffic Safety Study by Northwestern were presented for information only at the December 5, 1997 Building and Operating Committee meeting and the December 19, 1997 Board meeting so that the Board members and the public would have the opportunity to ask questions. Staff will present the information requested by Board members at the December Board meetings at the January 16, 1998 meeting of the Committee of the Whole. After the January 16, 1998 meeting, staff will analyze the comments and input from Caltrans (if and when received) as well as the comments and input from the Board and from the public, and develop more definitive and complete costs for the project. It is anticipated that this phase of the process will be completed by March, and the results presented to the Board. Thereafter, the matter will be presented to the Board with an analysis of the pros and cons of installation of a moveable median barrier for an efficiently focused discussion.

The decision-making process will involve a weighing and balancing of the various tradeoffs involved in either installing or not installing the one foot moveable median barrier. To facilitate that process, it may be helpful to further define and focus the issues involved.

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The central question is, given the current safety and operational status of the Golden Gate Bridge, whether or not the projected benefits of installation of the moveable median barrier outweigh the potential risks and adverse impacts that such installation might involve.

The issues encompassed within the central question can be broken down into two types: 1) those which must be determined in order to reach a conceptual decision of whether or not to install the moveable median barrier, and 2) those which must still be resolved even if a determination were made, conceptually, in favor of such installation. It would appear that resolution of the latter category of issues can be deferred until a conceptual decision is reached so that unnecessary costs can be avoided if the conceptual decision is against installation of the moveable median barrier.

Opinions may vary as to the relative weight of various issues and as to which category they belong. Following is a proposed breakdown, offered as an analytical tool to aid the Board in reaching a decision.

- A. Issues to be resolved in order to reach a conceptual decision of whether or not to install the moveable median barrier.
 1. Issues relating to reduced width of traffic lanes:
 - Lateral positioning of moveable median barrier
 - width of curb lanes and lanes adjacent to barrier.
 - Possible elimination of raised lane markers and possible alternatives.
 - Potential effects of above on safety: overall accident frequency and severity/crossover accident frequency and severity.
 - Potential effects of above on traffic operations.
 - effects on traffic flow generally.
 - effects on bus and truck operations.
 2. Issues relating to presence of a moveable median barrier on the Bridge.
 - Lateral deflection and effect of opposing traffic: likelihood, frequency, effect.

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- Rebound off barrier and effect on traffic in same direction.
- Presumed elimination of crossover accidents.
- 3. Issues relating to loss of sight distance.
 - Effect of higher brake warning lights on vehicles since 1985.
- B. Issues which still must be resolved even if a conceptual decision to install the moveable median barrier is made.
 1. Development of an acceptable end treatment and anchorage system for the San Francisco end of the barrier.
 2. Development of an acceptable guidance system for the transfer vehicles.
 3. Design of transfer vehicles.
 4. Provision for, and design and location of facilities for storage and maintenance of transfer vehicles.
 5. Development of procedures for emergency vehicle response.

Of course, as indicated above, in order to make an informed decision, the Board will need more complete and definitive estimates of costs which staff will attempt to develop in the interim.

We will be guided by the Committee regarding its schedule for further discussion and action. The proposed process is the joint recommendation of staff and Directors Boro, Read, and Smith, who were appointed to serve as an advisory committee on this project.

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